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REPORT ON RESULTS OF A STATE-WIDE FIELD TEST OF THE 35MM AERIAL PHOTOGRAPHY SYSTEM

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INTRODUCTION

The public land manager must use every tool available to him to gather the kinds of data he needs to make sound management decisions. In most cases, he needs the right kind of data rather than more data.

The 35mm aerial photography system arose because there was a need at the field level for a practical, safe, and economical tool to monitor resource changes. BLM personnel in the Malta District and in the Montana State Office joined with Dr. Merle Meyer of the College of Forestry, University of Minnesota to test the system on a small scale. Without Dr. Meyer's guidance and enthusiasm it is doubtful if the state-wide field test would have ever occurred. As a result of several summers of equipment testing, the components of the system were developed.

With the support of the Standards and Technology Staff at the Denver Service Center, we developed a comprehensive state-wide field test plan to fully evaluate the system. Thirty-five district personnel attended a workshop in Billings last May under the direction of Merle Meyer and the Montana State Office. The purpose of the week long workshop was to thoroughly train these personnel in the operation of the system and discuss the plan for the field test. Personnel from DSC and other agencies were also in attendance.

A copy of the Operating Manual - 35MM Aerial Photography System developed by Merle Meyer is included in Appendix B at the conclusion of the report. This manual describes all the components of the system; equipment, flight operations, analysis techniques, and applications. It was the basis for our district training program.

The following report is a summary of the six district evaluations submitted at the conclusion of the field test.

FIELD TEST PROCEDURES

The detailed plan for the field test of the 35mm aerial photography system (Instruction Memorandum MSO 73-45) is included in Appendix A (Attachment 1). As stated in the memorandum, the field test was developed to be comprehensive enough to evaluate the system fairly while at the same time not become so time consuming

as to interfere with the districts meeting priority program deadlines. By getting at least one man per resource area involved, we were generally able to distribute the workload in such a way so as not to seriously impact ongoing district programs.

As noted in the Instruction Memo, we encouraged those area and staff specialists that had the opportunity, to improvise and explore applications that we didn't specifically ask their district to work on. We were pleased that this did occur; especially in the wildlife and surface disturbance activities.

Each district submitted a formal report covering the results of their analysis on January 15, 1974.

TEST RESULTS & CONCLUSIONS

The six field reports were carefully evaluated by personnel in the Division of Resources at the Montana State Office. In order to present the results in a clear and concise form, each activity (range, watershed, etc.) will be covered individually. Prints are included in the report where appropriate. However, all district analysis was performed from 35mm slides.

Range Management:

A total of 21 two hundred foot transects were established, photographed, and analyzed by district personnel in Montana. The districts were instructed to establish these transects in key areas having important range, watershed, and wildlife values. Fourteen of the transects were flown twice during the year. For seven of the transects, a second flight was not accomplished due to one of the following reasons: personnel transfers, district workloads did not permit a reflight, or an insufficient commitment of time by the district man.

A summary table showing comparisons of ground and photo readings is enclosed (Table 1). For 18 of the transects, vegetation and litter were grouped together in the table to provide a more meaningful expression of ground cover versus bare ground. Data

for the final three transects show litter and bare ground combined, since the district man felt strongly that his photos were showing this.

We feel that the quantitative data gathered from the 35mm color infrared slides taken near peak-of-green (June) show a high degree of correlation with the field data. On 14 of the transects, both the estimates of ground cover (vegetation and litter, or vegetation alone) and of bare ground (or litter and bare ground) varied by 10 percent or less between field and slide analysis. We believe that the poorer correlation shown on the remaining seven transects is due to the following: slides of inferior quality due to improper exposure, photography not at vegetative peak-of-green, or a lack of field checking prior to analysis. The improper exposure problems could have easily been rectified if the photographer had experimented with several different f/stops while he was in the air. We encouraged this type of experimentation at the training session, prior to the field test.

The table indicates to us that in Montana, color infrared slides taken in June provide for better analysis than those taken later in the summer. This is because the peak-of-green of the vegetation occurs early in the summer and over a relatively short time interval. This peak-of-green period is the period of maximum infrared reflectance. As the summer progresses, the vegetation cures quickly, thus the infrared reflectance drops and analysis is much more difficult.

The identification of individual species is possible, given three factors: peak-of-green photos of high quality are obtained, adequate field checking is done, and the species has a dense enough growth form and distinctive enough color tone to separate it from other species or communities.

It was obvious from the field reports that those individuals that field checked with the slides during the summer had a much easier and more accurate analysis in the fall. The data illustrates that time spent field checking the slide with a viewer will substantially improve the quality and quantity of data gathered while significantly shortening the analysis time because the interpretor has confidence in his ability to work with the slides.

TABLE 1 COMPARATIVE RANGE TRANSECT READINGS FROM 1:3,200 SCALE 35mm COLOR INFRARED SLIDES

Transect No.	Field Data: Veg. & Litter (%)	Field Data: Bare ground (%)	Data from 35mm Color Infrared Slides — June: Veg & Litter (%)	June: Bare ground (%)	July or August: Veg & Litter (%)	July or August: Bare Ground (%)
1	81	14	83	15	78	21
2	50	43	56	44	65	32
3	75	22	78	21	87	10
4	42	57	51	48	49	45
5	96	4	97	3	-	-
6	70	30	74	26	75	25
7	57	42	74	25	73	27
8	50	42	66	32	86	14
9	48	36	60	40	-	-
10	56	44	67	32	54	46
11	63	35	65	35	61	39
12	93	7	96	4	92	8
13	55	45	61	39	64	36
14	78	19	88	7	88	7
15	65	33	82	18	-	-
16	83	16	83	16	-	-
17	83	11	86	13	-	-
18	74	12	68	12	-	-

Transect No.	Field Data: Veg. (%)	Field Data: Litter & Bare ground (%)	Data from 35mm Slides — June: Veg. (%)	June: Litter & Bare ground (%)	July or August: Veg. (%)	July or August: Litter & Bareground (%)
19	52	48	60	40	-	-
20	65	35	78	22	72	28
21	41	59	49	51	49	51

An analysis technique involving projecting the slide onto a rearview screen and simply delineating major resource features on acetate overlays proved highly successful. The districts felt that this technique would be of great benefit in monitoring range trend. The slide can be projected to a comfortable working scale and resource features such as vegetative communities or key species noted on the acetate. Nothing more need be done until the evaluation year. At that time, the new slide can be projected through the overlay from the past year and changes can be noted. Indications of trend such as changes in composition of key plant communities or changes in the size of bare open areas can easily and quickly be recorded using this general analysis technique.

To illustrate how effectively this technique can monitor resource changes, a 1971-1973 photo comparison is included (Figures 1 & 2). Each photo includes an overlay showing the types of features we can monitor and the ease with which significant changes can be seen.

This transect is located in a rest-rotation grazing system. The significant changes shown by this simple photo comparison tell the resource manager that the grazing formula is achieving desirable results. This type of analysis eliminates the built-in error between data gathered by different individuals. The man evaluating the results in 1973, can look at both slides and make the evaluation. As long as he is consistent in his criteria when analyzing both slides, he will obtain a meaningful and accurate estimate of the trend. This provides for more continuity in the decision making process.

An example of a well located transect in a key area is illustrated in Figure 3.

In a few instances, utilization of certain species can be monitored (Figure 4). However, at this point in time, we don't have any data to suggest that this could be done on most native rangeland.

The Field Solicitor in Billings has informed us that he sees many uses for 35mm photography in our range litigations. A copy of his memo on the subject is included in Appendix A (Attachment 2).

1971 Photo

Figure 1 - July 1971, color infrared photo at 1:3,000 scale, covering approximately 2 acres on the ground. The boundaries of key vegetative communities (rose, snowberry, green needlegrass, and western wheatgrass) that should be monitored, are delineated on the overlay(C).Barren areas are outlined to monitor changes in size over time(A & B).

1973 Photo

Figure 2 - July 1973, photo comparison. Note the tremendous change in the extent of the snowberry and rose plant community and the increased ground cover as compared to Figure 1. A land manager can rely on a photo comparison like this when the time comes to evaluate the grazing system.

Figure 3 - Example of a 200' transect. The scale is 1:3,200 and approximately 2 acres show on the photo. Note the 3 whitish colored targets. The center one marks the 100' point on the transect. A variety of important vegetative species (Little bluestem, Silver sagebrush, Upland rose, etc.) can be monitored. The transect crosses a small drainage which will allow us to monitor several watershed features. The Little bluestem (Andropogon scoparius) communities are outlined.

Figure 4 - This photo shows utilization of Sweetclover (Melilotus officinalus) by livestock outside an exclosure. The ungrazed plants (pink color) inside the fences are lush and vigorous and reflect highly. The scale of this photo is 1:12,000 (coverage is 30 acres).

We would conclude the following from the district reports relative to range management applications for this system:

- The system can monitor changes in ground cover, bare ground and species composition.

- We can monitor changes in the boundaries of key plant communities.

- Meaningful analysis of the slides is most directly related to three things: the care taken when selecting the transect location, proper field checking procedures prior to analysis, and quality of the photography.

- Ground-photo correlations for percent bare ground and percent total vegetation are high. Close correlations for percent litter are difficult on most transects.

- Given high quality slides, individual species of bunch-grasses and shrubs can be accurately monitored.

- We can monitor the vegetative response to various range improvement practices.

- In the case of a homogeneous type of grazing allotment, one or two carefully located key areas of 2-3 acres in size can be accurately and quickly monitored periodically using the 35mm system. More diverse allotments will require additional study areas.

- The general type of analysis using acetate overlays to monitor community changes used in combination with quantitative data gathered from the slide, will allow the resource manager to monitor range trend and further aid him in making sound management decisions.

- The interpretation of photos with ground cover of approximately 50 percent or less can be accomplished with relative ease. In areas of denser vegetation, interpretation of quantitative data is more difficult and we must rely on the changes in key plant communities.

- For safety reasons, no transects should be established in areas such as non-navigable canyons, therefore, transect location is restricted to some extent.

- The Field Solicitor in Billings assured us that the aerial photography could be used as evidence in grazing litigations.

Watershed Management:

One feature that is extremely important as an indicator of the erosion condition and susceptibility of our watersheds is the amount and type of ground cover present. As stated in the previous section of this report, percent ground cover and percent bare ground can be monitored accurately using 35mm color infrared aerial photography.

Many of the minute details we now gather as part of our watershed work cannot be seen from the air. We should concentrate on those items that we can see and use them as indicators. Whatever features are used, percent ground cover will surely be a dominant factor.

To illustrate the ability of the 35mm system to monitor important watershed changes, an interesting photo comparison is enclosed (Figures 5 & 6). It is a June-July comparison of a problem watershed in northern Montana. Figure 6 (July) shows the significant erosion activity that has occurred as a result of a high intensity rainstorm. Note the rilling and gullying that has occurred on the bare areas. The increased ground cover and associated changes in the boundaries of plant communities are good watershed indicators.

The 35mm system has the ability to gather more detailed watershed information if needed. For greater detail, a longer focal length lens (200mm, 300mm) may be used. Figure 7 illustrates photography using a 200mm lens, resulting in a scale of approximately 1:1,500. Using the longer lenses, we can obtain large scales while flying at safe altitudes (1000' minimum). Note on Figure 7 the amount of plant pedestalling that is occurring along with the obvious soil movement.

The 35mm system provides an inexpensive tool to assist us in monitoring deteriorating watersheds. Active headcutting can be photographed periodically to show us if our management practices

Figure 5 - Color infrared photo at 1:3,000 scale taken during June 1972, covering approximately 2 acres. Note the relatively high percentage of bare soil (white areas).

Figure 6 - Comparison taken one month later (July) showing the impact of a high intensity rainstorm. Note the significant gullying and rilling that has occurred. Also note the increase in ground cover, especially on the heavy grass type. The viewer has to be careful not to confuse high soil moisture with ground cover in this case. The important point is, we can see important changes as they occur. To illustrate these changes, compare points A-A_1, B-B_1 and C-C_1, on Figures 5 & 6.

Figure 7 - Large scale photo (approximately 1:1,500) showing detailed watershed features such as plant pedestalling (A), soil accumulation (B), and rilling (C). With the increased shutter speed of the new 35mm cameras and longer focal length lenses, we believe that quantifiable watershed parameters can be monitored. Ground coverage is about 1/2 acre.

Figure 8 - This photo is at a scale of 1:3,000 (2 acres) and shows the erosion damage associated with an active headcut. The dark band of soil across the lip of the cut (D) is about to sluff off. If targets are used to establish scale, accurate measurements of the progress of the cut can be determined. If the drainage starts to heal, we should see more vegetation appearing in the gully.

are producing the desired results, see Figure 8. The advance of active headcuts can be measured by the 35mm slides.

As part of the field test, two districts were asked to periodically photograph stream gauging stations with color and color infrared film to determine if turbidity can be monitored. Their results show that color infrared film is superior for this job. Major fluctuations in turbidity correlate with color tones as indicated in Table 2 - Sediment Concentrations and Color Tones.

Table 2
Sediment Concentrations and Color Tones

Site A

Date	Sediment Reading (PPM)	Photo Color
June 5	486	cream color
June 30	247	med. blue
August 1	low (no reading available)	dark blue

Site B

Date	Sediment Reading (Mg/L)	Photo Color
June 21	234	light turquoise
June 28	189	mod.-dark blue
July 10	207	mod.-dark blue
Sept. 5	309	light mod. blue
Sept. 12	72	olive green
Sept. 26	32	dark greenish blue

We would expect a creamy-light blue tone would be associated with high sediment and turbidity readings and a dark blue-black tone associated with lower sediment levels. The data from both sites tend to confirm this.

A similar study was performed in the Malta District in 1972 (Appendix A - Attachment 3), showing a very favorable correlation between general color tones and reservoir turbidity. Periodic photography of selected reservoirs and drainages will allow us to identify problem watersheds and plan our programs accordingly.

Figure 9 - This is a color photo showing an area where mine tailings are eroding. The tailings appearing yellow are weathered and are stable (E). The tailings that are white in color are eroding and must be watched (F).

In certain areas of the state, the movements of mine tailings present a real problem. Such an area is the Little Rocky Mountains in northcentral Montana. Tailings from past gold mining activity are washing down close to town and out onto the flat. The watershed specialist in the district feels that 35mm aerial photos of selected points along the route of the tailings will show him which areas are stable and which are eroding (Figure 9). He found color film to be superior for identifying weathered (stable) tailings.

We conclude the following from the field test reports relative to watershed applications:

- Our ability to observe changes in vegetative cover and bare ground using the 35mm system provides us with a strong indication of the present condition and susceptibility of our watersheds.

- Deteriorating watersheds can be identified and monitored by photographing such features as headcuts in drainages and turbidity in reservoirs and streams.

- Special problems such as the movement of mine tailings can be monitored by photographing selected locations on affected areas.

Wildlife Management:

Four districts evaluated the wildlife applications during the field test.

A mule deer winter range was studied to determine if meaningful estimates of Bitterbrush (*Purshia tridentata*) decadence could be obtained from the color infrared slides (Figure 10). Two sites were flown in June and August at scales of 1:6,700 and 1:2,700. The following table summarizes the results of this analysis.

Site A

Decadence (ground method - Cole transect)	26%
Decadence (from 35mm slide - June)	21%

Figure 10 - Color infrared 35mm photo of a Bitterbrush (Purshia tridentata) mule deer winter range. An example of a mature Bitterbrush plant that has a low amount of decadence is illustrated in coordinate Q-13. The decadent parts of the plant are steel-blue in color. The plant at O-20 appears about 50 percent decadent.

Site B

Decadence (ground method - Cole transect)	20%
Decadence (from 35mm slide - June)	9%

An explanation of the two methods of decadence determination is needed or the data will be misleading. The 26 percent decadence for Bitterbrush on Site A was derived by looking at a shrub, and if 25 percent or more of the shrub was decadent, then the shrub was recorded as a decadent plant. (This was a field observation on 50 shrubs.)

The percent decadence from IR slides was determined by looking at 50 shrubs and recording that portion of each shrub appearing to be decadent. An overall percent decadence for the stand was obtained by averaging all of the recorded figures. The difference in the two sets of data is that the Cole transect indicates 26 percent of the shrubs have 25 percent or greater decadence and the IR data shows an overall stand decadence of 21 percent.

The data for Site B shows this difference clearly. The Cole transects estimate that 20 percent of the plants are classified as decadent, while the 35mm slide estimates an overall stand decadence of nine percent. The district wildlife biologist did extensive field checking of individual plants and feels that his estimate of stand decadence from the slide is a good one. He feels that the June photo at approximately 1:2,700 scale gave the best results.

In another district, the wildlife biologist investigated the ability of the 35mm system to estimate canopy cover of Horizontal juniper (Juniperus horizontalis) on an important mule deer winter range. His results were as follows:

Juniper Canopy Cover (ground method-modified Daubenmire)	40.6%
Juniper Canopy Cover (from the 35mm slides)	46.0%

The ground data was gathered using a modification of the Daubenmire method (1959) whereby 20 4x10 dm plots are used to estimate canopy cover. Twenty plots were located on the slide and canopy cover estimated. As the data shows, the results of the analysis of the slides were very accurate when compared to the ground data.

An application for the system that the field test showed to hold great promise, is monitoring growth and activities of prairie dog towns on the National Resource Lands (Figure 11). Two types of data can be gathered quickly and inexpensively from the slides:

1. The outer boundary can be monitored to illustrate growth or decline in the size of the town.

2. Abandoned areas within this town can be monitored to see if the vegetation is responding to a rest-rotation grazing system initiated by the BLM.

By making color prints from the slides, one district constructed a mosaic of a dog town (Figure 12). The mosaic was used for illustrative purposes at the District Advisory Board Meeting. This technique was found to greatly enhance the district presentation as well as clarify the situation for the board members.

Because of the high quality vegetative data that color infrared photography gives us, it has been found to be a valuable tool in evaluating wildlife habitat. Waterfowl specialists are interested in gathering data on quantity and quality of shoreline, emerged, and submerged vegetation associated with water developments. Gathering this information on reservoirs with 3-5 surface acres of water using the conventional ground techniques may take up to two days. This same job was accomplished from a 35mm slide in two hours (Figure 13). In addition, an assessment of the success of our program to construct islands for nesting habitat can be accomplished with the system.

Studies have been conducted in the Malta District since 1970, using 35mm aerial photography to assess reservoir and stockponds for waterfowl management. A copy of a report by Merle Meyer, Bob Eng, and Frank Gjersing is included in Appendix A (Attachment 4).

The following conclusions can be drawn from the district reports:

- The system provides a valuable tool to assist the district wildlife biologist in assessing a variety of wildlife habitats as well as gathering important data regarding species composition, decadence of certain species, and canopy coverage on important browse communities.

Figure 11 - Color infrared photo at 1:20,000 (70 acres) showing part of a prairie dog town. Two important types of information can be gathered; growth of the town by watching the outer boundary, and success of grazing systems in revegetating abandoned areas within the town.

Figure 12 - This is a photo of the district mosaic of the dog town. The entire town can be photographed and the prints easily mosaiced together to provide a meaningful illustration of the present situation. These mosaics are especially valuable at public meetings.

Figure 13 - Color infrared photo of a reservoir containing important waterfowl habitat. Note the emergent vegetation along the edge of the water on the left side of the photo (A). The boundary of submergent vegetation out in the middle of the reservoir is plainly visible (B). Note the well vegetated island (goose nesting habitat).

- Both color and color infrared film have merit depending on season of photography and shrub species involved. In many areas, they compliment each other.

- Where browse plants exist in moderate densities and scattered plant communities, species differentiation can be accomplished with high accuracy. Some difficulty in species identification arises in dense stands of shrub cover (coulee bottoms) where many species are present, because of overlap in color tones.

- The assessment of waterfowl habitat can be accomplished quickly and accurately from 35mm color infrared slides.

- Prairie dog towns can be monitored rapidly and economically. Photo mosaics were found to be of great benefit.

<u>Forest Management</u>:

Prior to the field test, we had hopes that the 35mm system could assist our foresters in their seedling survival studies. An aerial inventory technique would result in significant time savings.

Our foresters report that for the system to be useful for seedling survival studies, we must be able to detect seedlings 6"-15" in height (three years old). To insure safe operations, none of our photography is flown at less than 1,000 feet above ground datum. The resulting scale (using 135mm lens) is approximately 1:3,000. At this scale the seedlings could not be separated from the surrounding vegetation. Two factors contributed to this: the competing vegetation was vigorous during that time of year, and spindly seedlings of this size just don't show at this scale. Two things may improve our ability to determine seedling survival; flying when competing vegetation is dormant and using a longer focal length lens to enlarge our scale.

Our field test confirmed the ability of color infrared aerial photography to monitor insect damage (<u>Figure 14</u>). The district work showed success in separating healthy trees from those infected but retaining needles or those completely dead. In an area of significant insect attack, it appears vigor differences among individual trees of the same species can be determined. These lower vigor trees may be more susceptible to future attacks.

Figure 14 - An example of an area infested with Pine Bark Beetle. The bright red trees are healthy. Those trees appearing light pink have been recently attacked, while those appearing green are dead. Although this photo is at about 1:3,000 scale, we feel insect damage can best be monitored at scales of 1:20-30,000.

One of our districts suggested using the 35mm system this summer on six areas identified for future timber sanitation operations. As a before and after comparison to check the success of the sanitation cuts, this system would provide significant savings of manpower and time.

We conclude that the system has the following forestry applications:

- We can monitor insect infestations and provide for a more efficient and complete follow-up sanitation operation.

- We can monitor revegetation following wildfires and prescribed burns.

- The progress of timber harvesting operations can be recorded.

- Timber trespass can be documented.

- We can monitor the progress of road construction as related to timber management.

<u>Mining and Surface Protection</u>:

No activities are in need of a monitoring tool like the 35mm system more than minerals and surface protection. With the extensive exploration and mining operations occurring on public lands, we must start now to photographically monitor these activities and their associated effects. Sequencial photography showing pre-mining versus post-mining conditions and the success or failure of reclamation is a powerful tool.

This past summer, the following types of mining were photographed: past gold mining in the Little Rocky Mountains, coal strip-mining in southeastern and central Montana, and bentonite activities in northern Montana. <u>Figure 15</u> shows clearly the comparison between reclamation of a coal strip-mine where topsoil was replaced versus where it was not. The slide shows that the success of revegetation is much higher on the topsoiled sites. Vertical aerial photos are superior to ground aspect photos for monitoring reclamation because accurate estimates of vegetative density can be gathered only from the aerial slides. <u>Figure 16</u> shows a

__Figure 15__ - This photo shows the higher reclamation success associated with replacing of the topsoil. The areas appearing bright red (good vegetative density - T) have been topsoiled. The areas where the topsoil was not replaced, show a lower vegetative density (U).

__Figure 16__ - A photo of a portion of the Decker Mine showing the coal seam, spoil banks, and reclamation attempts (R).

Figure 17 - Surface disturbance caused by motorcycles near Helena, Montana. Note 4-wheel vehicle trail also. The color infrared film shows surface disturbances better than color film does.

Figure 18 - This surface damage was caused by National Guard tanks. The disturbance can be quite severe and many of these areas heal very slowly.

portion of the Decker strip-mine and associated reclamation attempts.

Surface disturbances of many kinds were photographed this summer. In addition to the mining disturbances, off-road vehicle (ORV) uses of several types were monitored: including motorcycle hill-climb damage near Helena (Figure 17), and surface damage as a result of a National Guard SLUP for tank maneuvers (Figure 18).

From the district reports, we conclude the following:

- The 35mm system is a rapid method of recording the progress of mineral exploration, ongoing mining operations, and reclamation. In Montana, the types of operations monitored would include: oil and gas, coal, uranium, bentonite, gold, and geothermal steam.
- Surface disturbances of many kinds can be monitored. This would include ORV use, mining disturbances, and oil spills. The Field Solicitor in Billings has informed us he sees many uses for slides such as these in litigation (Appendix A - Attachment 2).

Additional Applications:

Three additional applications for the 35mm system have proven to be of great value. A brief description of each follows:

1. Maintenance

Inventories of the maintenance needs on water developments are an extremely expensive and time consuming process. Many miles of dike systems are walked. Many hours are spent traveling between reservoirs.

During this past field season, the 35mm system proved to be a valuable tool for assessing maintenance needs. Waterspreader systems covering many acres can be quickly inventoried from color infrared slides at scales of 1:20,000 - 1:35,000. Such features as breaks in dikes, headcutting around dikes, pipes

and drop structures washed out, and pipes in detention dams that have rusted out are plainly visible (Figures 19-20). Estimates of maintenance costs can be determined.

2. Evaluation of Historical & Archeological Sites

Because color infrared film is especially sensitive to differences in vegetation, past land use practices can often be determined by using vegetative patterns as indicators. These vegetative patterns can help reconstruct ghost towns and historical sites (Figure 21). Fort C. F. Smith, an army post occupied in the 1860's was photographed in an attempt to assist in reconstruction. The slides show clearly the location of the barracks and sections of the walls.

Color infrared slides can assist us in the location of archeological sites. Indian encampments can be located by spotting teepee rings (Figure 22). We must locate and monitor these areas in order to protect them.

3. Saline Seep

Each year thousands of acres of land in Montana are lost to saline seep. Although much of the land that is affected is agricultural land, a serious problem exists on the native rangelands also.

On the rangelands, the saline problem can be caused by many things, including the following: overgrazing--resulting in excess moisture accumulation in the subsurface, seepage from a water development, or a buildup in salinity originating on adjacent farm lands.

Based on previous work, it appears that color infrared film may be able to detect soils where this saline problem is in its initial stages. If these areas can be located, we can attempt corrective action before the problem becomes so critical that we lose all vegetative cover.

We believe that the 35mm system can assist us in the saline seep problem in two ways: we can monitor the rate of spread, and we have the capability to inventory those areas affected

Figure 19 - The dam on the left side of the photo has washed out (D). District engineers say they feel they can estimate the maintenance cost from the photo. In a state like Montana, where we have a tremendous number of water developments to inventory, the 35mm system can be a real time-saver.

Figure 20 - This color infrared photo shows a portion of a waterspreader system. The scale of the photo is 1:20,000, covering approximately 70 acres. Note the break in the dike that has developed (A). Note also the differences in soil moisture and vegetation that are apparent. The districts found the 35mm system to be a real time-saver for maintenance inventories of these waterspreader systems.

Figure 21 - This is a color infrared photo of the historic town of Garnet, Montana - east of Missoula. We are interested in reconstructing the town and this photo provides a rapid and inexpensive tool to assist us in this task. Vegetative patterns may indicate the location of old building foundations or other past land uses.

Figure 22 - This color photo shows Indian teepee rings (T). In most cases, the only way to count these rings accurately is from the air because many of them are only partially intact and would be missed on the ground.

on an allotment by allotment basis. The system is primarily designed to monitor smaller areas, but by changing lenses and altitudes we do have the flexibility to look at larger areas also.

Figures 23 - 26 illustrate the type of problem that saline seep presents to the land manager and the ability of the 35mm system to assist us. Figures 23 & 24 were provided to us courtesy of Mr. Marvin Miller of the Montana Bureau of Mines & Technology in Butte, Montana.

Figure 23 - An oblique color infrared photo showing an example of saline seep and its association with adjoining agricultural lands. On this site, the native rangelands are being seriously affected by saline seep.

Figure 24 - An oblique photo further illustrating the extent to which both range and farm lands are affected.

Figure 25 - A vertical color infrared photo taken with the 35mm system. The scale is 1:15,000 and about 50 acres of surface are shown. Note that the ranch in the photo is completely surrounded by saline areas (white colored). These saline areas are void of vegetative cover in most instances.

Figure 26 - This is a color photo at 1:4,200 scale covering 4 surface areas. The saline areas show white on the photo. Note that the area in the lower left corner of the photo(s) is starting to show a salinity problem. The 35mm system can quickly monitor areas such as this to tell us if this area is relatively stable or deteriorating.

We conclude the following from the field test reports:

- The system is a rapid, economical and accurate method of assessing maintenance needs and costs relating to water developments.

- 35 mm aerial photos can be of significant benefit in the reconstruction of historical sites and protection of archeological sites.

- The system provides a rapid method to detect and monitor areas where saline seep is a serious problem.

Summary:

The equipment used by the districts during the field test worked well. With proper care, the Minolta motor-drive cameras, camera mounts, and rear projection viewing screens are reliable and sturdy pieces of equipment.

We feel that for many applications, no ground targeting is necessary. Use of natural features (fences, reservoirs, drainages, rock outcrops, etc.) in place of targets is preferable. This would cut down on the time needed to establish and maintain transects.

Any targeting system must meet the following criteria: easy to establish, requires little maintenance, and is easily seen from the air. Where targeting is necessary to establish accurate scale, painted field stones can be used. However, on areas of low ground cover, these rock targets are difficult to see from the air. Several different targeting materials were used during the tests and some were found to be very successful.

The results of the field test brought out one point very clearly. The benefits derived from using the 35mm system are directly related to the amount of interest exhibited by the person using the system. If he locates his transects in key areas, takes the time to become proficient at the photography and field checking, improvises where he can improve the system, and performs thorough analysis, his results will show it. If he is not really interested in studies in general, this system will be of no benefit. The number of applications for this system is limited only by our willingness to use it.

The system provides the resource manager an excellent tool for acquiring aerial photography immediately and transferring it to a map base for quick analysis. In this regard, the Dillon District report stated "35mm aerial photography is particularly adapted to the monitoring of special projects such as mineral exploration, special land-use permits, off-road vehicle use, reclamation projects, and water turbidity. This is one of the few tools available to the districts to be used without relying on outside help. The independence allows us to act more swiftly in gathering data on unprogrammed projects that carry special importance".

We recognize the 35mm system cannot gather the same type of range-watershed-wildlife-forestry, etc., data acquired during ground surveys without flying dangerously low (300 ft.). On the other hand, certain resource features and details are readily apparent on the aerial photography, but obscure at ground level. Conventional ground data acquisition methods are generally single purpose oriented, i.e., range and watershed specialists monitor primarily ground cover and erosional features, but each discipline utilizes

different criteria or study procedures, while wildlife specialists are concerned primarily with browse condition. In analyzing such data, a provincial attitude generally prevails and faulty conclusions or wrong decisions result. The 35mm system offers the decision maker an opportunity to assess range-watershed-wildlife factors together rather than singularly. The resultant trend index or condition rating is an expression of a combination of range-watershed-wildlife factors, thus giving the decision maker a complete picture of the cumulative effects of any given land use. Figures 27 - 29 illustrate an actual situation in which 35mm aerial photography provided a resource manager with better data on which to make a sound decision.

Gathering quantitative data from year to year as required under conventional methods, generally by different observers, has cast a shadow on the reliability of such data. Opponents of existing study methodology feel that human inaccuracy substantially limits the utility of the data for making decisions. The 35mm system will eliminate or mitigate data discrepancies that result from the human factor. The method of analysis is designed so one individual will gather quantitative data from the year-one slide and the evaluation year slide. The evaluator can establish certain interpretation criteria and thus analyze each slide uniformly.

As mentioned throughout this report, the quality of the photography is one of the most important factors affecting the success of analysis. Becoming proficient in using the system requires a willingness on the part of the field man to experiment with different camera settings, filters, air speeds, altitudes, lenses, and applications. As a result of our work in Montana, we feel we now know which combination of these various factors yield the best results for our specific needs. However, our f/stops, air speeds, and altitudes may not be the best ones for a district in Arizona or Utah. The knowledge and experience that the field man brings to this system are what makes it successful. His willingness to improvise and experiment will improve the system even further and make the system fit his particular needs.

Several of our districts have identified a need in the district for a staff specialist working in remote sensing. His primary duties would consist of the following:

- Responsibility for the district 35mm program. He would take the pictures, assist the field man in locating study areas, field checking, and analysis. He would handle all 35mm training in the district.

Figure 27 -
September 1968 aspect photo showing fenceline contrast between a heavily grazed area (A--grazed June 1 - November 30) and an ungrazed exclosure (B).

Figure 28 -
Photo comparison - September 1970. Area (A) has been completely rested from livestock this year. This aspect shot could lead the manager to conclude that (A) has recovered to such an extent that (A) and (B) have similar amounts of ground cover.

Figure 29 -
A color infrared aerial photo also taken in September 1970 at 1:3,200 scale (2 acres). This photo tells the manager that (A) still has significantly less ground cover than (B). If the manager has to make a decision regarding a request from the rancher to run more livestock, this 35mm aerial photo would indicate to him that he should perhaps wait another cycle before granting the request.

- Interpretation and mapping projects with 9"x9" color or color infrared aerial photography. The primary thrust here would be toward URA's and MFP's.

- Where applicable, encourage the use of additional remote sensing techniques (satellite, U-2, thermal scanning) at the district level.

These remote sensing systems can be used at the field level to assist the land manager in doing his job. The cost of the interpretive equipment is not prohibitive.

RECOMMENDATIONS

As a result of the field test, we recommend the following:

1. The BLM adopt the 35mm Aerial Photography System as an alternative primary studies system for the range, watershed, and wildlife activities. Our field personnel are called upon to make many critical management decisions. The test shows that the 35mm system gathers certain types of data more efficiently and meaningfully than our ground techniques do. We must not tie the hands of the field man. He must have the opportunity to use all available tools in order to do his job.

2. In support of the first recommendation, we urge adoption of the 35mm system by all activities. As a tool capable of monitoring a variety of resource changes, the system has applications for nearly all activities including the following: forestry, recreation (including historical and archeological sites), minerals, surface protection, maintenance, and special problems such as saline seep.

   The 35mm Aerial Photography System provides the BLM resource manager with an accurate, economical, and rapid tool to aid him in monitoring important changes on the National Resource Lands. This will improve our ability to make sound management decisions.

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

STATE OFFICE
316 NORTH 26th STREET
BILLINGS, MONTANA 59101

ATTACHMENT #1

MAY 11 1973

Instruction Memorandum MSO 73-45
Expires 12/31/73

To: District Managers - Montana

From: State Director - Montana

Subject: Field Testing 35mm Aerial Photography Method

Following is Attachment #1

The method will be field tested in six districts in Montana during the spring, summer, and fall of 1973. Through districts, state office and DSC personnel will be involved directly or indirectly in the field test.

In order to fully evaluate the applications and limitations of the system, it is imperative that the method be exposed to a wide variety of resource conditions and managers at the field level. The method has been tested in one district (Malta District). Our primary objective was to develop a method and test cameras and determine if we could monitor resource changes. We found that the method has application possibilities beyond our greatest expectations. Based on the preliminary investigation, it would be impossible for one district or a few individuals to fully evaluate the method; thus the study was expanded to include a variety of resource specialists associated with varied and complex resource conditions.

To insure that data gathered during the field test can be quickly and accurately evaluated and analyzed, it will be necessary to develop a fairly comprehensive plan. It is our intention to design the study plan so that it does not interfere with meeting priority program deadlines and distribute the workload to insure that district programs are not seriously impacted.

Each district is expected to gather certain basic information. However, it is not our intention to restrict investigation of all possible applications. If funds and manpower are available, we encourage this.

IN REPLY REFER TO

930: 1740

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

STATE OFFICE
316 NORTH 26TH STREET
BILLINGS, MONTANA 59101

ATTACHMENT #1

MAY 11 1973

Instruction Memorandum MSO 73-45
Expires 12/31/73

To: District Managers - Montana

From: State Director - Montana

Subject: Field Testing 35mm Aerial Photography Method

The method will be field tested in six districts in Montana during the spring, summer, and fall of 1973. About 35 districts, state office and DSC personnel will be involved directly or indirectly in the field test.

In order to fully evaluate the applications and limitations of the system, it is imperative that the method be subjected to a wide variety of resource conditions and managers at the field level. The method has been tested in one district (Malta District). Our primary objective was to develop equipment and test cameras; and determine if we could monitor resource changes. We found that the method has application possibilities beyond our greatest expectations. Based on the preliminary investigation, it would be impossible for one district or a few individuals to fully evaluate the method; thus the study was expanded to include a variety of resource specialists associated with varied and complex resource conditions.

To insure that data gathered during the field test can be quickly and accurately evaluated and analyzed, it will be necessary to develop a fairly comprehensive plan. It is our intention to design the study plan so that it does not interfere with meeting priority program deadlines and distribute the workload to insure that district programs are not seriously impacted.

Each district is expected to gather certain basic information. However, it is not our intention to restrict investigation of all possible applications. If funds and manpower are available, we encourage this.

The procedures for testing the application of the method in various resource activities by district are as follows:

1. Range, wildlife and watershed - all districts.

   a. Select two (2) key types in each resource area. For the purpose of this study, key areas will have wildlife, watershed, and range values.

   b. Establish one (1) 200' line transect on each key area and mark the 0', 100' and 200' points on the ground with painted rock targets. The transects will be established under the conditions defined in Table 1.

   c. Fly and photograph each transect as follows:

      (1) Peak of green cool season herbaceous vegetation (June).

      (2) Peak of green warm season herbaceous vegetation (July or August).

   d. Gather base line information on the ground for June flight only.

      (1) Sample 200 points on each transect using the step-toe transect method. Three parallel transects will be established. The base transect will be targeted on the ground. The other transects are established at 50' intervals and parallel to the base.

      (2) Using Attachment A - "Resource Field Data Record" form record the following information:

      - Vegetation hits by species
      - Bare ground
      - Litter
      - Large rock
      - Erosion condition rating or SSF
      - Browse hits-record: Age class, and percent decadence

   e. Interpret cool season and warm season aerial photography for above information in the office using rearview projection screen and slide projector. Compile base line and aerial photography data in the format shown in Attachment B.

f. Lewistown and Miles City District Wildlife Specialists will establish a minimum of one (1) transect each in a valuable browse type.

Primary Objective - Determine the optimum season, scale, and film for gathering information on browse. As a minimum determine if the system has the capabilities to:

(1) Differentiate between various browse species.

(2) Percent decadence.

(3) Age class.

(4) Crown intercept.

(5) Pellet groups or other signs.

(6) Annual and perennial forbs.

Establish transects as explained in Part 1.b. Each transect will be analyzed as follows:

(1) Fly - spring, summer, and fall.

(2) Film - color and color infrared photography of each flight.

(3) Scale (flying height 1200') - 55mm lens, 135mm and 200 or 300mm lens each flight.

Ground truth or base line information will be gathered only during the spring reading.

g. Watershed specialist in Malta and Billings will determine if chemical quality and sediment levels can be monitored using this system. Streams with gauging stations that collect the aforementioned data will be monitored periodically during the spring, summer, and fall; i.e., Clarks Fork at Edgar in Billings District and Fred Robinson Bridge (referred to as Missouri River near Landusky) in Malta District.

Procedure

(1) Fly gauging stations weekly beginning May 25 - June 29, then on July 27, August 31, and September 28.

(2) Photograph gauging station area using color and color infrared photography at approximately 1200' using 135mm lens.

(3) Determine if color tones on photography correlate with gauging station data.

h. Prepare a report and discuss fully field test findings, assemble the quantitative data in the format shown in 1.e, and recommendations for application of the method by resource area. Also, discuss problems and recommended solutions.

2. Forestry - Missoula and Dillon.

a. Determine when or stage insect infestation can be detected on photography.

b. Determine if tree seedling survival can be monitored using this method.

3. Archeology and Recreation - Miles City and Billings.

a. Photograph known archeologic sites and determine which scale or film type yields the best results.

b. Photograph areas with heavy ORV travel and determine if effects are evident on the photography.

4. History (as designated).

a. Test the system for reconstructing historical sites. Photograph the following sites using a 55mm lens at 2000':

(1) Fort C. F. Smith (Billings District).

(2) Battle of Cow Island (Malta District).

(3) Fort Keogh - Bismarck Stage Route and determine stage stops.

(4) Try to locate trading and Army post at mouth of Judith (Lewistown District).

(5) Ft. McKenzie (near mouth of Marias) (Malta District).

(6) Site of "Stoneville Battle" - northwest of Alzada (T. 9 S., R. 59 E., Section 24) (Miles City District).

(7) Madison River Toll Bridge (T. 3 S., R. 1 E., Section 2, SE¼NW¼) (Dillon District).

(8) Glendale (T. 2 S., R. 10 W., Section 25, Lot 3, SW¼NE¼) (Dillon District).

5. Surface Disturbance - Dillon and Miles City.

a. Monitor mining exploration activities in Dillon.

b. Monitor changes in the Decker Strip Mine (Miles City).

6. Maintenance Program - Malta.

a. Photograph reservoirs and dike systems need maintenance and determine if adequate project estimates could be made from the 35mm aerial photographs.

As mentioned earlier, we encourage district personnel to use their imagination during the field test. All activities will prepare comprehensive reports pertaining to the application of this method and discuss problems and recommended solutions.

During the aerial photography workshop, members of my staff will review the contents of this memorandum with the trainees.

Edwin Zaidlicz

Enclosures - 3
Encl. 1-Attachment A
Encl. 2-Table 1
Encl. 3-Attachment B

Data Required by Forestry [ ] Lands [ ] Livestock [ ] Recreation [ ] Watershed [ ] Wildlife [ ] Big Game [ ] Upland Wildlife [ ]

District ______ Date ______ Recorder ______ Resource Area ______ Planning Unit ______

Location ___ ¼ ___ ¼ Sec. ___ T. ___ R. ___ Cooperator ______ Slope% ______ Exposure ______ Elevation ______

Wildlife Habitat Mgt. Area ______ Herd Unit ______ Watershed Area ______

Allotment ______ Pasture ______ Class Livestock ______ Season Use ______ Management System ______

Key Species ______

Transect No. ______ Perm. [ ] Temp. [ ]

Photo Trend Plot No. ______

Acres Represented ______ % of Subtype ______

Vegetation Type (Sub) ______

Principal Wildlife Species			
Season of use			

Section 1

Line Transect Data (100 points)
(BLM 7322.11B3)

Litter: P, persistent; N, nonpersistent; last less than 2 years. B, bare ground; L, large rock; S, small rock; Attr. species

Browse Key Species (additional data), age & form class

Section 2

Species																	
Species																	

FORM CLASSES

Hedging: Little	Moderate	Severe	Available	Little	Moderate	Severe
1	2	3	All None	7	7	7
4	5	6	Part Dead	8	8	8

AGE CLASS

S, Seedling; Y, Young; M, Mature; D, Decadent, R, Resprout
(BLM 6630)

BROWSE UTILIZATION - (TWIG NUMBER)

	Species		TOTAL
UTILIZED			
NOT UTILIZED			
	(BLM 6630)		

Surf. [illegible]	0 1 2 3	4 5 6	7 8	9 10 11	12 13 14
rface Rock	0 1 2	3 4 5	6 7 8	9 10 11	12 13 14
edestalling	0 1 2 3	4 5 6	7 8 9	10 11 12	13 14
Rills	0 1 2 3	4 5 6	7 8 9	10 11 12	13 14
Flow Patterns	0 1 2 3	4 5 6	7 8 9	10 11 12	13 14 15
ullies	0 1 2 3	4 5 6	7 8 9	10 11 12	13 14 15
oil Movement	0 1 2 3	4 5	6 7 8	9 10 11	12 13 14
(Use 7310-12 base rating)					Present SSF

Estimated Future SSF Without Mgmt.	
" " " With Intensive Mgmt.	
" " " With Treatment & Mgmt.	
Estimated Production Capacity (In 100 Lbs.)	
(BLM 7322.1186 and .1188a)	

PHOTO TAKEN

Yes ☐ No ☐ Photo No. ______

Size Plot B&W ☐

☐ 3x3 ☐ 5x5 Color ☐

Forestry ____ Lands ____

Livestock ____ Recreation ____

Watershed ____ Wildlife ____

OIL DATA:	½" to 4"	4" to (ERD) ______
exture		
H		
olor		
arent aterial		

LM 7322.1185

TREATMENT OPPORTUNITIES:	TYPE
Chemical	
Mechanical	
Watershed Tillage	
Water Control	
Other*	

Precipitation______ J____F____M____A____M____J____J____A____S____O____N____D____

annual (long term average-10 years plus) monthly

Moisture Source: On-Site☐ Run-in☐ Run-off☐ Run through☐

SEDIMENT YIELD FACTOR RATING

SURFACE GEOLOGY (a)	SOILS (b)	CLIMATE (c)	RUNOFF (d)	TOPOGRAPHY (e)
(10) . Marine shales and related mudstones and siltstones	(10) a. Fine textured; easily dispersed; saline-alkaline; high shrink-swell characteristics b. Single grain silts and fine sands	(10) a. Storms of several days' duration with short periods of tense rainfall b. Frequent intense convective storms c. Freeze-thaw occurrence	(10) a. High peak flows per unit area b. Large volume of flow per unit area	(20) a. Steep upland slopes (in excess of 30%) b. High relief; little or no floodplain development
(5) . Rocks of medium hardness . Moderately weathered . Moderately fractured	(5) a. Medium textured soil b. Occasional rock fragments c. Caliche layers	(5) a. Storms of moderate duration and intensity b. Infrequent convective storms	(5) a. Moderate peak flows per unit area b. Moderate volume of flow per unit area	(10) a. Moderate upland slopes (less than 20%) b. Moderate fan or floodplain development
(0) . Massive, hard formations	(0) a. High percentage of rock fragments b. Aggregated clays c. High in organic matter	(0) a. Humid climate with rainfall of low intensity b. Precipitation in form of snow c. Arid climate, low intensity storms d. Arid climate; rare convective storms	(0) a. Low peak flows per unit area b. Low volume of runoff per unit area c. Rare runoff events	(0) a. Gentle upland slopes (less than 5%) b. Extensive alluvial plains
actor value				

GROUND COVER (f)	LAND USE (g)	UPLAND EROSION (h)	CHANNEL EROSION AND SEDIMENT TRANSPORT (i)
(10) ound cover does not exceed % Vegetation sparse; little or no litter No rock in surface soil	(10) a. More than 50% cultivated b. Almost all of area intensively grazed c. All of area recently burned	(25) a. More than 50% of the area characterized by rill and gully or landslide erosion	(25) a. Eroding banks continuously or at frequent intervals with large depths and long flow duration b. Active headcuts and degradation in tributary channels
(0) ver not exceeding 40% Noticeable litter If trees present understory not well developed	(0) a. Less than 25% culvivated b. 50% or less recently logged c. Less than 50% intensively grazed d. Ordinary road and other construction	(10) a. About 25% of the area characterized by rill and gully or landslide erosion b. Wind erosion with deposition in stream channels	(10) a. Moderate flow depths, medium flow duration with occasionally eroding banks or bed
(-10) Area completely protected by vegetation, rock fragments, litter [illegible] opportunity for rainfall to reach erodible material	(-10) a. No cultivation b. No recent logging c. Low intensity grazing	(0) a. No apparent signs of erosion	(0) a. Wide shallow channels with flat gradients and short flow duration b. Channels in massive rock, large boulders, or well vegetated c. Artificially controlled channels
ctor value			

Subtotal (a)-(g) | Subtotal (h)-(i) | Total Rating ______ ac. ft./sq. mi./yr.

Table 1

R.A.	1/ Ground Cover Low 10-30%	Mod. 31-59%	High 60-95%	Grazing Treatment Rest Pasture	Graze Pasture
Blaine 2/	X	X		X	X
Phillips		X	X	X	X
Valley	X	X		X	X
Prairie		X	X	X	X
Big Dry	X	X		X	X
Powder River		X	X	X	X
South Dakota	X	X		X	X
Apsuroka		X	X	X	X
Yellowstone	X	X		X	X
Judith River		X	X	X	X
Musselshell	X	X		X	X
Lewis & Clark		X	X	X	X
Sacajawea	X	X		X	X
Garnet		X	X	X	X

1/ Includes only litter and live vegetation.

2/ As an example, this means that two transects will be established in the Blaine Resource Area, one transect will be located in a rest pasture with 10-30% ground cover, the other in a grazed pasture with 31-59% ground cover, or vice versa.

APPENDIX B

Attachment B

Compilation Sheet

	Data Type	Transcect 1: 1/ Base Line	Transect 1: Aerial Photography: 2/ June Photo.	Transect 1: Aerial Photography: 3/ Aug. Photo.	Transect 2: 1/ Base Line	Transect 2: Aerial Photography: June Photo.	Transect 2: Aerial Photography: Aug. Photo.
	4/ Live Vegetation						
Key asses							
Key rubs							
ey rbs							
	Bare Ground						
	Litter						
	Large Rock						
	SSF						
Key rowse ecies	Percent Decadence						
	Age Class						
	Percent Decadence						
	Age Class						
	Percent Decadence						
	Age Class						

1/ Ground truth data gathered during June.

2/ Actually peak of green cool season vegetation.

3/ Actually peak of green warm season vegetation.

4/ Record live vegetation hits, other than key species.

United States Department of the Interior

IN REPLY REFER TO:

OFFICE OF THE SOLICITOR

ATTACHMENT #2

P. O. Box 1538
Billings, Montana 59103

March 7, 1974

Memorandum

To: Division of Resources, BLM
Attention: Dick Cosgriffe

From: Field Solicitor, Billings

Subject: Potential uses of color infrared aerial photography in litigation involving the Bureau of Land Management

Reference is made to the Range Watershed and Wildlife Work Shop presented by your office February 26 through March 1. Please allow me to extend my compliments to you and to other members of the Bureau of Land Management staff who made these meetings possible. I found the discussions and presentations to be of uniformly high quality and of stimulating content.

Reference is also made to our conversations concerning color infrared aerial photography and its potential use in various types of litigation involving the Bureau of Land Management. Of particular interest to me is the potential for use in administrative hearings involving range decisions by District Managers concerning carrying capacity or changes in carrying capacity. I believe that the color infrared photograph would be of great assistance to me, as your attorney, in presenting the Bureau of Land Management's case in administrative proceedings of this nature. The aerial photographs could be used in two manners: (1) as demonstrative evidence merely depicting the lands as photographed and allowing some testimony therefrom with respect to changes in trends, and (2) as an approved professional proceeding for monitoring trends in the Federal range as correlated with on-the-ground intensive surveys.

My particular interest, as noted above, is the ease with which changes in trends can be ascertained using this method. I felt that some of the presentations by the District Offices very readily pointed out upward or downward trend changes as a result of your management procedures. In addition to the use as evidence in administrative hearings for grazing matters, color

infrared photography could be utilized in ascertaining areas of timber trespass, mining disturbances, and success of reclamation of mined lands, all of which are of great interest to this office as your attorneys.

I additionally believe that over a period of years, as expertise is developed in more individuals, preceding years' photographs can be easily compared and read with respect to trend changes, as opposed to the complete and total loss of employees due to transfers who have made on-the-ground range surveys. I further believe that use of color infrared photography will allow the Resource Manager to more constantly monitor greater portions of the area within his responsibility, thereby more rapidly bring to light problem areas which may require additional on-the-ground reconnaissance.

If you have any questions with respect to this matter or if we could be of any further assistance to you, please feel free to call upon this office.

Richard K. Aldrich
For the Field Solicitor

2b-

R+W.—

ATTACHMENT #3

UNITED STATES GOVERNMENT

Memorandum

TO : District Manager

DATE: August 19, 1972

FROM : Dick Page and Glen Stickley

SUBJECT: Summary - J. T. U. readings/Infrared Photography Correlation for Stock Ponds in south Phillips County

Data collected from four stock ponds in south Phillips County is as follows:

Pond Identification	Jackson-Turbidity Units Reading	Color on Infrared Film
Sec. 2, T.21N., R.27E.	10	Dark green to black
Sec. 25, T.29N., R.27E.	34	Dark green to black
Red Fox	137	Turquoise green
Hoss	466	Pale robin egg blue

Based on these four and other unrecorded field observations it is possible to predict particle concentration in surface water from infrared aerial photographs. The gradient from the clearest to those heavy with particles correlates well with the dark green to light blue-green and beige photographed pond colors. Further monitoring with the field Hack Kit is needed to establish some J. T. U. readings in the intermediate photographed color range.

The attached notes on each pond and its watershed as determined from the infrared aerial photographs correlates well with the turbidity measurements. Where low ground cover and other poor watershed conditions exist the ponds are highly turbid.

Some useful projections based on turbidity measurements might be potential pond life, watershed condition trend, and ground cover requirements for improved water quality.

Richard Page
Valen G. Stickley

cc: State Office (930)

RPage/kfh - 8/19/72

ATTACHMENT #4

WATERFOWL MANAGEMENT APPLICATIONS OF COLOR IR

35mm aerial photography is being used for Northern Great Plains stock pond and reservoir assessment for waterfowl management.

Merle P. Meyer
Univ. Minn. Coll. For.
St. Paul, MN 55101

Robert L. Eng
Dept. Ento. and Zool.
Mont. State Univ.
Bozeman, MT 59715

Frank N. Gjersing
Mont. Game and Fish Dept.
Havre, MT 59501

ABSTRACT

With larger numbers of water-holding structures being developed in the Great Plains, waterfowl production potentials are increasing. Simply creating new water surfaces, however, is no guarantee of waterfowl attraction. Due to excessive ground distances between stock ponds, a special 35mm aerial photography/mapping system was developed and a study of known reservoirs instituted in 1970 on the Bureau of Land Management's Malta District in Montana. Tests of such interacting factors as films, filters, scales, vegetation and water conditions, resulted in a practical

1/Published as Sci. Jour. Ser. Paper No. of the Univ. of Minn. Agr. Expt. Sta., and Sci. Jour. Ser. Paper No. of the Mont. State Univ. Agr. Expt. Sta.

system of stock pond assessment with color IR 35mm aerial photography. The system makes it possible to determine the following for operational purposes: (a) amount, location and characteristics of emergent and submergent vegetation, (b) water condition, and (c) status of potential nesting areas.

INTRODUCTION

Classically, the prime waterfowl producing area in North America has been a region referred to as the prairie pothole region which includes parts of Alberta, Saskatchewan, Manitoba, Minnesota, North and South Dakota and Montana. This same area embraces very productive farmland and in the past 25 years, increasingly intensive agricultural activities have resulted in a drastic reduction in marshland.

To the west of the prairie pothole region, and particularly in the western Dakotas and eastern Montana, is a large block of land, much of which is grazing land. In contrast to the pothole region, more intensified grazing management in this area has resulted in increased water areas in the form of stock ponds. Much of this land is in public ownership, administered by the U.S. Department of Interior, Bureau of Land Management, and this agency has constructed nearly 8,000 stock ponds in eastern Montana alone (Jones, 1970). In addition, many stock ponds are constructed annually by other agencies and by private landowners. Several studies have pointed out the significance of stock ponds as

regards waterfowl production (Bue et al, 1952; Smith, 1953) and others have indicated specific characteristics of stock ponds which enhance waterfowl production (Berg, 1956; Jones, 1970; Gjersing, 1971).

As grazing management becomes more intensified and other uses such as waterfowl production are incorporated into management plans, land managers who are responsible for large acreages must have speedier, more refined techniques for evaluating relative values of various resources. A 35mm color infrared aerial photography technique (Meyer et al. 1973), developed primarily for range vegetation trend analysis purposes (Meyer et al. 1973) appeared also to have considerable promise as a means for classifying stock pond potentials for waterfowl production. The system was, therefore, incorporated into an ongoing Montana State University/Bureau of Land Management study located on BLM's Malta District in northeastern Montana.

Specific characteristics which rate high in stock pond attractiveness to waterfowl, and (hopefully) subject to assessment with aerial photography, were the following:

1. Shoreline-surface acre ratios-- important in determining the number of breeding pairs a body of water will accomodate (Hochbaum, 1944).
2. Percent of pond supporting aquatic vegetation - this provides an index to its potential for waterfowl use,

particularly for brood rearing (Gjersing, 1971).

3. Degree of turbidity of pond water

4. Status of shoreline and adjacent vegetation as it relates to nesting cover.

PROCEDURE

An initial feasibility overflight of the study stock ponds was accomplished at vegetation "peak-of-green" in June, 1970. Aerochrome infrared film and a Wratten 12 filter were employed with a 9x9-inch format 6" focal length mapping camera to obtain scales of 1:4,000, 1:20,000 and 1:50,000. It was immediately obvious that this type of photography had definite possibilities at scales of 1:4,000 and smaller.

Since the development and testing of a 35mm aerial photography system for range trend analysis was already in progress in the same area, (Meyer, Eng, Gjersing, et al. 1973; Meyer, Cosgriffe, Linne, 1973) this project was established parallel to it. In fact, in some cases, test overflights for both purposes were undertaken at the same time. In both cases, a Minolta SR-M motordrive 35mm camera was used (Figure 1) in conjunction with the special mount (Figure 2). The mount requires no alteration of the aircraft and, since the camera can be slid into the aircraft, changes in film, filter, f/stop and exposure can be quickly accomplished. Additionally, the mount can be leveled prior to target area entry which results in photography sufficiently vertical in nature to permit

distance and area measurements.

Flight tests over the stock ponds were carried out through the summer of 1971 and into early summer, 1972. Among the variables tested were: films and filters - Ektachrome infrared/ Wratten 12, Kodachrome-X and Ektachrome-X with and without haze filters; shutter speeds - 1/250 to 1/1000-second; sun angle; lens focal lengths - 135mm, 100mm and 55mm; photo scale - from 1:3,000 to 1:15,000; vegetation stage; surface wind - assessing relative effects of water surface disturbance on depth penetration; and water turbidity - its identification and possible analysis.

Since some means of mapping the photography was necessary, two types of rear projection screen systems were developed and tested (Figure 3). Both were quite satisfactory, although the mirror type was more complicated and expensive since a first-surface mirror was required in order to avoid "shadow" images. Also, since reliable distance and area measurements were required, a means of establishing scale on the projected photographs was necessary. Although artificial targets were tried successfully (e.g., pie plates), small clusters of available field stones at known (paced) ground distances usually 150-200' apart on or near reservoir dams were more desirable - and relatively permanent.

RESULTS

Ektachrome infrared film used with a Wratten 12 filter was found to be superior to other film/filter combinations tested.

Not only did it provide a more visible waterline, but better portrayal of upland vegetation type, vigor and extent. This combination was also the most satisfactory for classification and mapping of aquatic vegetation. Emergents were usually clearly distinguishable from submergents and, where the water was relatively clear, the extent of submergents was easily detected and mapped.

Sun angle profoundly influenced photo quality, particularly when a sunspot appeared (or very nearly appeared) in the area of coverage. Even without a sunspot, however, a high sun angle (1-1½ hours either side of noon, sun-time) was undesirable because: (a) the lack of shadow made scale markers harder to discern, (b) with a low sun angle, water penetration was often possible even when a stiff surface breeze was blowing - which was not true with a high sun angle, (c) a low sun angle accentuated certain features such as shrub location and type, herbaceous plant community differences, relative plant vigor, comparative visibility of livestock trailing patterns and water turbidity.

The 55mm lens used at altitudes from about 1500 to 1800 feet provided the best working scale range (i.e., 1:8,000 to 1:10,000). Since it was desirable to include any one stock pond in a single line of pictures and, since stock pond sizes varied, it was sometimes necessary to change photo scale to accomodate

pond width. For smaller ponds, therefore, scales as large as 1:7,200 were used - for some of the larger ponds, however, scales as small as 1:11,000 were required, but still proved useful for pond mapping and evaluation.

Focal lengths shorter than 55mm were not useful because wider angles of coverage included too much aircraft fuselage and landing gear. Even 55mm lens photography included a thin slice of the fuselage, but this was found useful in providing a permanent record of flight direction for each set of pond coverage.

Variations in turbidity were quite obvious, although extreme care in classification was necessary in some cases. For example, a pond with clear, rather shallow water over a very light-colored bottom without vegetation could sometimes be confused with a pond with high turbidity. The key to separating these two water types was found at the margins of the pond - the clear-water pond invariably had a visible partial (narrow) fringe of submergent aquatics, whereas the pond with a great deal of suspended sediment had uniform discoloration to the water's edge, and no visible fringe.

Mapping the ponds is accomplished in the manner described by Meyer, Cosgriffe and Linne (1973). A grid transparency was placed in the slide projector and projected onto the screen at approximate working scale. The projected image was then "plumbed" to remove projection tilt by adjusting the position of the projector and/or rear projection screen. The stock pond transparency was then

projected and the scale of the projected image calculated by means of the ground targets. Features of interest were traced off on the acetate overlay, the scale calculated, and desired distances and areas determined (the latter by means of dot grid). In most cases, the complete task of setting up, adjusting the projection/mapping unit, interpretation, mapping, and distance and area calculations required a time input for one man not exceeding 45 minutes per pond.

Cost differences between ground and aerial photo methods are rather significant - although not subject to comparison on all counts. For example, it is difficult (if not impossible) in many cases to map the extent of submergent vegetation in the field. Generally, however, the analysis of a stock pond in the field, depending upon the the distance and difficulty of overland travel to it, will require anywhere from 1/2 to 1 full day.

In July of 1972, 15 reservoirs were photographed in an area 50-75 miles from point of takeoff at the Malta District Office in Montana. Actual flying time was slightly under three hours - totaling $90 aircraft time and 1 manday for the photographer/ interpreter (includes planning, preparation for flight, caring for and mailing film). Film purchase and processing costs were about $25.00. Total analysis time for the 15 reservoirs was slightly under 2 mandays. This total outlay of 3 mandays plus $115 for aircraft and photography compares favorably with the

10-plus mandays and related ground transportation (approximately 1300 miles at 12-15¢/mile), which would be required for an approximately equivalent on-the-ground analysis.

CONCLUSION

Two seasons of trials with 35mm color infrared aerial photography indicate its ability to economically, and efficiently, estimate the following: shoreline-surface area ratios; percent of stock pond supporting aquatic vegetation; classification of aquatic vegetation to species, or at least to submergent and emergent types, with a minimum of ground sampling; and degree of turbidity.

It appears that by assigning an index to the above-mentioned values, as well as to the condition of the shoreline vegetation, overall pond indices may be arrived at which will permit classifying ponds to relative waterfowl use potential.

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